97-D-102, Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT), Los Alamos National Laboratory, Los Alamos, New Mexico

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

Significant Changes

The initial capability of the Phase 2 containment vessel was to contain detonations up to the equivalent of 124 pounds of TNT equivalent. A recent review of the near-term and long-term hydro-testing program indicates that this capability is not necessary to satisfy the emissions limits defined in the Record of Decision (ROD). Reducing the containment vessel capability for detonations significantly reduces the physical size of the vessel and correspondingly reduces the size of the Vessel Preparation Facility, which reduces the future cost risk for this project.

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1988 Budget Request	1Q 1988	N/A [a]	4Q 1988	4Q 1990	30,000	N/A [b]
FY 1989 Budget Request	3Q 1988	N/A [a]	4Q 1988	4Q 1990	53,400	N/A [b]
FY 1990 Budget Request	3Q 1988	N/A [a]	4Q 1988	4Q 1992	53,400	N/A [b]
FY 1991 Budget Request	3Q 1988	N/A [a]	2Q 1989	4Q 1992	53,400	N/A [b]
FY 1992 Budget Request	3Q 1988	1Q 1995	2Q 1989	4Q 1994	53,400	N/A [c]
FY 1993 Budget Request	3Q 1988	1Q 1995	2Q 1989	4Q 1994	53,400	N/A [c]
FY 1994 Budget Request	3Q 1988	1Q 1995	2Q 1989	3Q 1997	81,400	85,600
FY 1995 Budget Request	3Q 1988	4Q 1995	2Q 1989	3Q 1997	81,400	85,600
FY 1996 Budget Request	3Q 1988	4Q 1995	2Q 1989	3Q 1998	81,400	85,600
FY 1997 Budget Request	3Q 1988	4Q 1995	3Q 1989	1Q 1999	105,700	114,760
FY 1998 Budget Request	3Q 1988	4Q 1995	3Q 1989	1Q 1999	186,700	199,210
FY 1999 Budget Request	3Q 1988	4Q 2000	3Q 1989	4Q 2002	259,700	269,800
FY 2000 Budget Request	3Q 1988	4Q 2000	3Q 1989	4Q 2002	259,700	269,800
FY 2001 Budget Request *(Current Baseline Estimate)* [d]	3Q 1988	4Q 2000	3Q 1989	4Q 2002	259,700	269,800

[a] There was no requirement for A-E duration or completion date during these fiscal years and, therefore, this information is not available.

[b] There was no requirement for TPC during these fiscal years and, therefore, this information is not available.

[c] During these fiscal years, the project was delayed while completing the Accelerator Development Plan in order to verify plans and budgets and, therefore, this information is not available.

[d] Due to the complicated history of this project as described in Section 3, and the fact that it has two distinct phases, it is not possible to identify the specific year for Preliminary Estimate and Title I Baseline.

2. Financial Schedule [a]

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
1988	1,800	1,800	201
1989	9,700	9,700	2,912
1990	10,905 [b]	10,905	10,767
1991	5,000 [c]	5,000	7,558
1992	0	0	5,139
1993	3,500 [d]	3,500	2,643
1994	17,000	17,000	5,881
1995	17,000	3,000	6,159
1996	16,495	19,495	5,045
1997	0	11,000	23,873
1998	46,300 [e]	46,300	37,681
1999	36,000	36,000	43,900
2000	60,768 [f]	60,768	59,038
2001	35,232	35,232	41,447
2002	0	0	7,456

3. Project Description, Justification and Scope

The Dual-Axis Radiographic Hydrotest Facility (DARHT) project was previously a subproject of the Nuclear Weapons Research, Development, and Testing Facilities Revitalization, Phase II project (88-D-106). With the virtual completion of the remaining ten subprojects in 88-D-106, the DARHT effort was established as a stand-alone project in FY 1997 so that it can be more readily managed, monitored and funded.

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[a] Funds appropriated in FY 1988-1996 are from the DARHT subproject 88-D-106 and were moved to 97-D-102 to support management and monitoring of the project.

[b] Reflects an appropriation of $15,760,000 and the subsequent sequestration of $4,855,000 for FY 1990 and the FY 1990 Omnibus reprogramming approved by appropriations subcommittees.

[c] Reflects an appropriation of $16,800,000 and the subsequent FY 1991 Omnibus reprogramming of $11,800,000 approved by Congressional subcommittee.

[d] No funds were appropriated in FY 1993. Reflects reprogramming of $3,500,000 redirected from prior year appropriation from Dormitories subproject of Line Item 88-D-106 at the Nevada Test Site (NTS).

[e] FY 1998 funding represents $24,300,000 for completion of Phase 1 (first-axis) and $22,000,000 for engineering planning and long-lead procurement for Phase 2.

[f] Original appropriation was $61,000,000. This was reduced by $232,000 for the FY 2000 rescission enacted by P.L. 106-113.

Justification

Since its inception in 1988, the DARHT project has been recognized as a key link in DOE efforts to maintain the quality and reliability of the nuclear weapons stockpile. Historically, radiographic hydrodynamic tests and dynamic experiments have been a requirement to support the DOE (and predecessor agencies) mission; they remain an important requirement for future efforts of the Stockpile Stewardship and Management (SS&M) Program as they assist in the understanding and evaluation of nuclear weapon performance. Dynamic experiments are used to gain information on the physical properties and dynamic behavior of materials used in nuclear weapons, including changes due to aging. Hydrodynamic tests are used to obtain diagnostic information on the behavior of a nuclear weapons primary (using simulated materials for the fissile materials in an actual weapon) and to evaluate the effects of aging on the nuclear weapons remaining in the greatly reduced stockpile. The information that comes from these types of tests and experiments cannot be obtained in any other way.

The DOE existing capability to obtain diagnostic information was designed and implemented at a time when the organization could rely on direct observations of the results of underground nuclear tests to provide definitive answers to questions regarding nuclear weapons performance. Without the ability to verify weapons performance through nuclear tests, the remaining diagnostic tools are inadequate by themselves to provide sufficient information. Accordingly, as the Nation moves away from nuclear testing, DOE must enhance its capability to use other tools to predict weapons safety, performance, and reliability. In particular, DOE must enhance its capability to perform hydrodynamic experiments to assess the condition and behavior of nuclear weapons primaries.

Although the current U.S. stockpile is considered to be safe and reliable, the existing weapons are aging beyond their initial design lifetimes and, by the turn of the century, the average age of the stockpile will be older than at any time in the past. To ensure continued confidence in the safety and reliability of the U.S. nuclear weapons stockpile, DOE needs to improve its radiographic hydrodynamic testing capability as soon as possible. Uncertainty in the behavior of the aging weapons in the enduring stockpile will continue to increase with the passage of time because existing testing techniques, by themselves, are not adequate to assess the safety, performance, and reliability of the weapons primaries. Should DOE need to repair or replace any age-affected components, retrofit existing weapons, or apply new technologies to existing weapons, existing techniques are not adequate to assure weapons safety and reliability. In an era without nuclear testing, DOE believes that it is probable that the existing weapons will require these types of repairs or retrofits in the foreseeable future. DOE has determined that no other currently available advanced techniques exist that could provide a level of information regarding nuclear weapons primaries comparable to that which could be obtained from enhanced radiographic hydrodynamic testing.

In addition to weapons work, DOE uses its radiographic testing facilities to support many other science missions, and needs to maintain or improve its radiographic testing capability for this purpose. Hydrodynamic tests and dynamic experiments are important tools for evaluating conventional munitions; for studying hydrodynamics, materials physics, and high-speed impact phenomena; and for assessing and developing techniques for disabling weapons produced by outside interests.

Project History Leading to Current Project Scope

Originally, the project scope included two 16-MeV electron-beam accelerators producing x-rays. In FY 1990, the Department decided to defer construction of the Hydrotest Firing Site (HFS) pending completion of technology development verified by the test results from an Integrated Test Stand (ITS), which consisted of about 30 percent of one x-ray machine. Following the successful ITS test results, development and construction of the hydrotest firing site was re-scoped based on the recommendations of two independent "Blue Ribbon" review committees assembled to assist the Department of Energy (DOE) in enhancing the development of a vital hydrotest capability. The new scope provided for the development, procurement, and installation of the first of two 16-MeV flash x-ray machines (for dual-axis radiography) at the firing site; and construction of a weatherproof building to house the dual-axis radiographic systems and supporting calibration activities. Construction was resumed in FY 1994.

On January 26, 1995, an injunction was issued for this project by the United States District Court for the District of New Mexico, requiring a cessation of all actions associated with the DARHT construction project, including any construction, procurement, design, or any furtherance of the DARHT project pending completion and judicial review of an Environmental Impact Statement (EIS) and Record of Decision (ROD). In response, the Department ceased all project activities and completed an EIS for the project. A ROD was published in October 1995. The preferred option that was selected was to complete the project and operate the DARHT facility with the use of steel containment vessels to minimize the environmental impacts from operation of the facility. This containment option includes multiple phases to eventually obtain at least 75 percent reduction in the emissions from high-explosives testing when compared to the DARHT Baseline Alternative analyzed in the EIS. The January 1995 injunction was lifted in April 1996 and DARHT construction resumed in May 1996.

The DARHT project is now redefined to comply with the ROD preferred alternative and is divided into two phases. The first phase, most of which has been in progress since FY 1988, consists of the construction of a Radiographic Support Laboratory (RSL) and a Hydrotest Firing Site (HFS), which includes the first of two flash x-ray machines. In addition, this phase includes: the initial stage of containment of emissions from the high-explosives experiments to be conducted at the facility; an increase in accelerator energy from 16 to 20 MeV; changes in the accelerator to generate higher electron-beam currents; and improved diagnostics. Phase 1 was completed during FY 1999 and the first axis became operational in July 1999. Phase 2 includes the second flash x-ray machine, as well as the second stage of increased containment of testing emissions. The Department's decision in September 1997 of the Long-Pulse Induction Accelerator as the best technology for the second axis resulted in the current baseline for the project. A third phase of increased containment of testing emissions as defined in the ROD will be evaluated after several years of operating experience on DARHT. If a decision is made at the time to develop a vessel system capable of containing a 400 pounds of TNT equivalent high explosives, a new line item would be proposed.

Phase 1

Phase 1, completed and approved for operations on July 3, 1999, includes the Radiographic Support Laboratory; the first of two flash x-ray machines (for dual-axis radiography) at the firing site; state-of-the-art hydrodiagnostic instrumentation at the firing site; a blastproof building to house the dual-axis radiographic systems and support calibration activities; and, the first containment vessel (an existing vessel design modified for DARHT testing).

Hydrotest Firing Site (HFS)

The entire HFS building was constructed as part of this phase, as well as the first x-ray machine and all electronic and optical diagnostics. The second machine, necessary to complete the essential dual-axis configuration of the facility, is being built in a sequential manner (Phase 2), allowing it to take advantage of engineering and scientific advances that occurred before its construction. The first machine is a state-of-the-art linear induction accelerator, producing an electron beam of approximately 20-MeV that is converted into an x-ray beam. A high speed electronic data acquisition system, a firing site control system, and optical imaging systems are included. Optical instrumentation includes high-speed framing and streak cameras and laser velocity interferometers. To improve the diagnostics capability of this facility, a gamma-ray camera is included.

The HFS building is a two-level, 39,650-square-foot building to house and operate both accelerators. The walls and roof are designed to shield personnel operating the facility from the radiation produced by the accelerators, as well as to resist blast forces resulting from the detonation of explosives. The accelerators are located on a three foot thick concrete slab on grade. Both accelerator rooms contain a total of approximately 13,175 square feet and are equipped with a 10-ton capacity bridge crane. Completion of the entire building for both x-ray machines allows installation of the second machine (Phase 2) to take place without stopping hydrodynamic testing activities on the first machine.

The power supply rooms provide space adjacent to the accelerators for electrical equipment that serves the accelerators. These rooms are equipped with 3-ton capacity bridge cranes. The detection chamber is electromagnetically shielded. Adjacent to the detection chamber are the control room, a cable room, a capacitor discharge unit (CDU) room, and a computer room. The detection chamber, computer room and accelerator control room are also provided with an access flooring system. Other rooms include an optical room, an analyzer room, a Fabry Perot room, a laser illumination room, an assembly room, toilets, and mechanical/electrical equipment room. This area contains approximately 26,475 square feet.

Fire protection is provided throughout by a hydraulically designed foam/water automatic sprinkler system. Plumbing and process piping includes hot and chilled circulating water, potable hot and cold water, industrial cool water, sanitary sewer, compressed air, natural gas, transformer oil, and low-conductivity water systems. A boiler and two chillers are included to provide hot and cold water. This conditioned water is used for heating, ventilating, and air-conditioning the building, with the exception of the detection chamber and accelerator control room, which are serviced with "computer-type" units. Two above-ground, 12,000 gallon oil storage tanks, a cooling tower, and an electrical substation are provided. Power is supplied to the building from an existing 13.2 kV line. The building is equipped with communication systems that include telephone, intercom, and broad band communications.

Site work includes a new asphalt surfaced access road, an asphalt surfaced circulation road and parking area, surface drainage, and erosion control. Utilities extended to the site include natural gas, water, electrical power, and communication services. A septic tank and seepage pit are provided to handle the sanitary sewage.

A prototype vessel system and a temporary cleanout unit are included to obtain the initial 5 percent reduction in testing emissions when compared to the DARHT Baseline Alternative analyzed in the EIS for the first five-year period of facility operation. The prototype vessel system is a modification of an existing steel vessel design for experiments containing up to 27 kg of high-explosives.

Phase 2

Included in DARHT Phase 2 is the second electron beam accelerator which will be installed in the second accelerator hall provided in Phase 1. The second machine, necessary to complete the essential dual-axis configuration of the facility, is being built in a sequential manner, allowing it to take advantage of engineering and scientific advances that have occurred since construction of the first machine. In September 1997, the Department selected the Long-Pulse Linear Induction Accelerator because it presented the greatest technological advancement for the lowest cost and least risk. The second machine will be capable of providing four high-quality beam pulses over four microseconds with each pulse comparable in quality to the single pulse machine in the first axis.

The technology selected for Phase 2 requires a machine that is longer than the accelerator hall provided under Phase 1. To accommodate the longer machine, it was necessary to increase the size of the west accelerator hall by 1,300 square feet. Other modifications that were required to the HFS included a larger roof hatch to install equipment, extension of the 3-foot thick accelerator foundation and glycol system modifications. While the HFS was constructed as part of Phase 1, the changes were driven by Phase 2 requirements and were, therefore, budgeted for in Phase 2.

A preparation facility includes high bay space for cleanout, process, and two staging areas. The high bay spaces will include bridge cranes. This facility includes a small analytical lab, change rooms, storage, waste storage, fabrication shop, a small multipurpose room, an area for office cubicles, and the mechanical/electrical support spaces.

Fire protection for the vessel preparation facility will be provided throughout by a hydraulically designed automatic sprinkler system. Areas with the potential for contamination will drain to a storage tank to provide secondary containment of the sprinkler water. The areas with the potential for contamination will also be connected to a mitigating debris recycling system. Other plumbing systems will be potable hot and cold water, hot and cold circulating water, a double wall drain line for potentially contaminated water, and sanitary waste drainage. A natural gas-fired boiler will provide the hot water and a chiller will provide the chilled water. The HVAC system will include a HEPA filtration system to vent the vessels. The areas with potential contamination will be designed for seven air changes per hour with a once-through air handling system. The analytical lab will be equipped with a fume hood. The building will be equipped with communication systems that will include telephone, intercom, and broad-bank communications.

Site work for the vessel preparation facility will include a new concrete apron. The apron will be designed for vessel handling equipment and storage. Utilities extended to the site will include natural gas, water, sanitary sewer, electrical power, and communication services. Power will be supplied to the building from an existing 13.2-kV line.

This phase includes a vessel capable of containing a detonation which results in a reduction in testing emissions of at least 40 percent, when compared to the DARHT Baseline Alternative analyzed in the EIS, during the second 5-year period of facility operation. Containment goals will be met or exceeded through the use of a combination of techniques: containment, material replacement, post-shot recovery, and program management.

Experience gained during Phases 1 and 2 will allow the final containment techniques to be implemented that would result in at least 75 percent reduction in testing emissions when compared to the DARHT Baseline Alternative analyzed in the EIS for the remaining years of facility operation. The Department of Energy will meet the release reduction goals of this phase through the use of the combination of techniques discussed above.

Project Milestones:

FY 1999:	Phase 1:	HFS Construction Complete	3Q
		First Axis Machine Operational	3Q
		Complete First Axis Readiness Assessment	3Q
	Phase 2:	Deliver Accelerator Cells to LANL for Prototype Testing with the Beam	4Q
FY 2000:	Phase 1:	Complete	
	Phase 2:	Complete Second Axis Machine Accelerator Hardware Design	1Q
		Complete Confinement Vessel Design	2Q
FY 2001:	Phase 2	Complete Design for Vessel Preparation Facility	1Q
		Start Vessel Preparation Facility Construction	2Q
		Complete Detector Design	2Q
		Complete Accelerator Hardware Procurement	3Q

4. Details of Cost Estimate [a]

Phase 1	(dollars in thousands) Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs (Design Drawings and Specifications)	23,776	23,959
Total Design Costs (22.5% of TEC)	23,776	23,959
Construction Phase		
Buildings	24,048	23,814
Special Equipment	48,075	46,804
Inspection, Design and Project Liaison, Testing, Checkout and Acceptance	2,787	2,032
Project Management (6.2% of TEC) [b]	6,506	6,439
Total Construction Costs (77% of TEC)	81,416	79,089
Contingencies		
Construction Phase (.5% of TEC)	508	2,652
Total Contingencies (.5% of TEC)	508	2,652
Total, Line Item Costs (TEC)	105,700	105,700

[a] The Details of Cost Estimate section has been split between Phase 1 and Phase 2 to more accurately reflect costs under the categories required under the current data sheet format. It is not possible to identify all costs in the new categories since this project was established and tracked using cost categories in effect at the time of initial funding in FY 1988.

[b] Since the project was initially funded in FY 1988, all of the Phase 1 management effort has been tracked only as project management; consequently, all design and construction management is included as project management under the construction phase.

4. Details of Cost Estimate

(continued)

Phase 2	(dollars in thousands) Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design Costs (Design Drawings and Specifications)	30,310	17,337
Design Management Costs (0.2% of TEC) [a]	273	273
Project Management Costs (0.2% of TEC) [a]	382	382
Total Design Costs (20.1% of TEC)	30,965	17,992
Construction Phase		
Buildings	7,040	9,370
Special Equipment	91,745	101,103
Inspection, Design and Project Liaison, Testing, Checkout and Acceptance	162	336
Construction Management (0.4% of TEC) [a]	637	637
Project Management (4.9%of TEC) [a]	7,573	8,832
Total Construction Costs (69.6%of TEC)	107,157	120,278
Contingencies		
Design Phase (2.3% of TEC)	3,500	2,902
Construction Phase (8.0% of TEC)	12,378	12,828
Total Contingencies (10.3% of TEC)	15,878	15,730
Total, Line Item Costs (TEC) [b] (Phase 2)	154,000	154,000
Total, Line Item Costs (TEC) (Phase 1)	105,700	105,700
Total, Line Item Costs (Phase 1 and Phase 2)	**259,700**	**259,700**

5. Method of Performance

Design and procurement of the conventional facilities were performed under negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

[a] Design and construction management only includes conventional facility design and construction. Design phase project management includes only conventional facility design phase management. Construction Phase project management includes both the conventional facility construction phase management and all of the special equipment project management. Special equipment does not have a traditional construction component with design, procurement and installation taking place concurrently among the various special equipment work elements. Attempting to separately track and report special equipment design and construction management would require establishing an additional 26 WBS elements and associated cost control elements. This is deemed to have greater cost than benefit. The intent to establish conventional facility construction design and construction management costs is supported, however, in this approach.

[b] Escalation rates taken from FY 1999 DOE escalation multiplier tables.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years*	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Costs						
Design	30,243	13,601	11,519	2,159	719	58,241
Construction	77,616	30,299	47,519	39,288	6,737	201,459
Total, Line item TEC	107,859	43,900	59,038	41,447	7,456	259,700
Operating expense funded equipment	1,105	0	0	0	0	1,105
Total Facility Costs (Federal and Non-Federal)	108,964	43,900	59,038	41,447	7,456	260,805
Other Project Costs						
R&D necessary to complete construction	1,471	0	0	0	0	1,471
Conceptual design costs	260	0	0	0	0	260
NEPA documentation costs	2,960	0	0	0	0	2,960
Other project-related costs [a]	2,803	461	0	0	1,040	4,304
Total, Other Project Costs	7,494	461	0	0	1,040	8,995
Total Project Cost (TPC)	116,458	44,361	59,038	41,447	8,496	269,800

7. Related Annual Funding Requirements

(FY 2002 dollars in thousands)

	Current Estimate	Previous Estimate
Annual facility operating costs [b]	10,400	10,400
Programmatic operating expenses directly related to the facility [c]	8,000	8,000
Total related annual funding (operating from FY 2002 through FY 2031)	18,400	18,400

[a] These are the costs for (1) FY 1997 Technology Options Study to evaluate the alternative technologies for the second x-ray machine, (2) facility start-up including the Readiness Assessment, and (3) management of operating expense items.

[b] These are all direct and indirect costs associated with maintaining the facility readiness for programmatic purposes. It includes facility maintenance, utility costs, space tax, organizational support, janitorial services, and security with both axes operational and in the final containment phase. It includes the RSL, HFS, and Vessel Preparation Facility. On average, the related effort is 28.5 FTEs.

[c] The annual programmatic operating expense will fluctuate significantly from year to year depending on the programmatic effort. The $8,000,000 is an average based on the FY 1997 effort at PHERMEX.